DOCUMENT RESUME

ED 076 566 SP 006 497

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TITLE	Effects of Teachers' Cognitive Demand Styles on Pupil Learning.
INSTITUTION	Indiana Univ., Bloomington. Center for Innovation in Teaching the Handicapped.
SPONS AGENCY	Bureau of Education for the Handicapped (DHEW/OE), Washington, D.C.
PUB DATE	Feb 73
GRANT	OEG-9-242178-4149-032
NOTE	39p.; Paper presented at the Annual Meeting of the American Educational Research Association, New Orleans, Louisiana, February 1973
EDRS PRICE	MF-$0.65 HC-$3.29
DESCRIPTORS	*Academic Achievement; *Cognitive Objectives; Concept Teaching; *Learning Processes; Recall (Psychological); Teacher Behavior; *Teaching Methods; *Teaching Styles

ABSTRACT

Two experiments were conducted to compare the effects of two different experimentally induced orientations toward lesson objectives on teachers' instructional behaviors and the consequent achievement of their pupils. In each experiment, 36 student teachers were randomly assigned to one of two treatments. Each treatment required the teachers to instruct the same course content to a randomly selected group of eight elementary pupils. One group was oriented to teach for a recall objective; the other was oriented toward a concept mastery objective. Both experiments yielded significant differences in patterns of teaching behaviors which were congruent with the specified objectives. The experiments also yielded significant differences between treatment groups in resultant pupil learning. Students in the recall treatment performed significantly better on the recall test. No differences were found on the concept mastery test. (Thirteen tables of statistical data are presented.) (Author/BRB)

Effects of Teachers' Cognitive Demand Styles on Pupil Learning[1]

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Stephen Hillman, and Susan Wisehart

February, 1973

Center for Innovation in Teaching the Handicapped

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This paper was presented at the annual meeting of
the American Educational Research Association,
New Orleans, February, 1973

[1]This research was supported by grant #OEG 9-242178-4149-032 from the U. S. Office of Education, Bureau of Education for the Handicapped to the Center for Innovation in Teaching the Handicapped. Contractors undertaking such projects under Government sponsorship are encouraged to express freely their professional judgment in the conduct of the project. Points of view or opinions stated do not, therefore, necessarily represent official Office of Education position or policy.

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Abstract

Two experiments were conducted to compare the effects of two different experimentally induced orientations toward lesson objectives on teachers' instructional behaviors and the consequent achievement of their pupils. In each experiment 36 student teachers were randomly assigned to one of two treatments. Each treatment required the teachers to teach a lesson from the same content to a randomly selected group of eight elementary pupils. Treatments differed in that one group was oriented to teach for a recall objective and the other group for a concept mastery objective.

Both experiments yielded significant differences in patterns of teaching behaviors that were congruent with types of objectives teachers were to seek. Both experiments also yielded significant differences between treatment groups in resultant pupil learning with students in the recall treatment performing significantly better on the recall test. No differences were found on the concept mastery test.

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Effects of Teachers' Cognitive Demand Styles on Pupil Learning

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Reviews of past research on effects of teacher behavior in general (Rosenshine & Furst, 1971) and teacher questions in particular (Hillman, 1972) have concluded that the kinds of questions teachers ask bear an important relationship to pupil learning outcomes. Hunkins (1967, 1968), for example, has shown that groups of students working on analysis-evaluation types of questions in relation to social studies text content materials scored significantly higher on posttests containing application and evaluation questions than students who had had questions stressing knowledge. Wright and Nuthall (1970), in looking at short-term effects of teacher behavior, found significant correlations between class achievement scores and six teacher behavior variables, including patterns and types of teacher questions and teacher reactions to pupil responses. Rothkopf and Bloom (1970) have shown that interactions (in the form of questioning) with teachers during reading lead to more effective study habits of written material. In general, then, these and other studies (e.g., Brophy & Good, 1970; Good, 1970) suggest quantitative differences in teacher interaction with high achieving and low achieving students.

As Rosenshine and Furst (1971) point out, however, only the sparsest evidence exists for systematic relationships between the cognitive features of teaching behaviors and student achievement. Most of the evidence is correlational and is limited to relationships between naturally occurring variations in teaching and student outcome measures. Studies, therefore, are needed which systematically manipulate teaching

behavior and base the pupil outcome measures specifically on what was taught and how it was taught.

The present study was designed to serve two main purposes. The first of these was to provide experimental evidence concerning the effects of teachers' cognitive demands on pupil learning outcomes. The second purpose was an attempt to secure data for the construct validation of the Individual Cognitive Demand Schedule (ICDS), a classroom observation instrument developed by two of the authors to record cognitively oriented instructional communication between the teacher and individual pupils in the classroom (Lynch & Ames, 1971b).

The ICDS was originally designed to record the cognitive level of the verbal interactions between teachers and children in classes for the educable mentally retarded in order to determine how these teachers individualize instruction through their differentially focused verbal interactions with individual pupils (Lynch & Ames, 1971a). The instrument codes teachers' "cognitive demands" and pupil responses into 11 categories of cognitive operations varying from simple identification and memory tasks to complex, abstract tasks requiring cognitive transformations and elaboration. Studies of instructional interactions in special education classes (Lynch & Ames, 1971a) and in regular elementary classes (Lynch & Ames, 1972) have demonstrated stylistic differences between teachers during instruction. Two experiments on modifying student teachers' cognitive demand styles demonstrated that some features are easily modified and adapted to both instructional goals and individual pupils (Lynch & Ames, 1971c). The ICDS has been used extensively in Project PRIME (Programmed Reentry Into Mainstream Education), a large-scale USOE evaluation project of innovative practices in Texas with handicapped children.

It was reasoned that, if the ICDS validly records significant cognitive instructional interactions, two randomly selected groups of teachers using the same informational content but teaching for contrasting types of objectives should exhibit different patterns of cognitive demands, each pattern being consistent with the objectives. Secondly, it was reasoned that students should differ in achievement on the two types of objectives consistent with their teachers' objectives and the types of cognitive demands experienced during instruction. In other words, certain categories of the ICDS were deemed more likely to occur in the attainment of specific instructional outcomes. Pupils of teachers providing more opportunities to respond with cognitive operations relevant to certain objectives should perform better on achievement test items requiring those operations.

Two experiments were conducted to examine these relationships. The experiments followed the same design (see Figure 1) but differed in

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Insert Figure 1 about here

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the age levels of the pupils taught. The subjects were student teachers enrolled in a year-long, field-based program for seniors in elementary education at Indiana University. In each experiment student teachers were randomly assigned to one of two set-inducing orientations on how to teach the lesson from the same content material. One group was instructed to teach for recall, the other for concept mastery. Each student teacher then taught a 30- or 40-minute lesson to a randomly selected group of eight pupils. The lesson was tape-recorded and coded on the ICDS. Twenty-four hours later the pupils were tested with an achievement test constructed to measure each of the two types of objectives.

Method

Subjects

Experiment I. Thirty-six student teachers in grades one, two, and three were assigned at random to each of the two treatment conditions. Treatment 1 was a set to teach for factual recall, and Treatment 2 was a set to teach for concept mastery. All student teachers had completed one full semester of their programs at the time of the experiment. Some unevenness of grade level assignments resulted from administrative decisions and the availability of classes for student teachers that were beyond the investigators' control. The eight children taught by each student teacher were randomly selected from the class to which the student teacher had been assigned for the semester. These classes were located in three different elementary schools.

Experiment II. Thirty-six student teachers in grades four, five, and six were assigned at random to each of two treatments. Treatment 1 was a set to teach for recall; Treatment 2 was a set to teach for concept mastery. Again, each student teacher taught eight children selected randomly from the student teacher's class. The classes were located in the same three schools used in Experiment I.

Lesson Materials

Experiment I. The lesson content was a 915-word article entitled "Why Birds Sing," an adaptation of an article that had appeared in a children's nature magazine. It was expanded and rewritten by the authors to assure vocabulary, syntax, and content clarity suitable for first-grade children. The key concepts in the article were "song" and "territory." The article elaborated on the relationship of a bird's song to the maintenance of his territory. It also contained a number of facts about

several types of birds, their habits, and the various kinds of sounds they make. The article was accompanied by hand-drawn picture of a house surrounded by trees and other objects, pictures of several types of birds, and a cat which could be cut out and placed on the house picture for purposes of illustration during the lesson.

Experiment II. The lesson content was an artificial code of 69 different symbols, each standing for a familiar English word. The symbols were based upon the "Rebus" symbols devised by Woodcock and Clark for the Peabody Rebus Reading Program (Woodcock & Clark, 1969). The present authors modified some of the original symbols and added new, more difficult symbols. The final set included six categories of symbols for which some rule could be stated concerning the relationship between the symbol and the type of word for which it stood. For example, a short horizontal line and an arrow in different positions relative to the line were used to symbolize prepositions denoting direction. The symbols ranged in difficulty, abstractness, and logical complexity from simple, pictorial representations of concrete objects ("chair") to familial relationships that were symbolized by abstract figures derived from a basic rectangular matrix whose dimensions represented sex, generational and intragenerational relationships. Each student teacher received a set of flash cards with each of the "Rebus" symbols on one side and their English equivalents on the other. In addition, each student teacher was furnished with a 250-word story written in "Rebus," with a copy for each child and a "teacher's version" containing the English translation.

Treatment--Induction of Lesson Orientation

Each experimental group of student teachers met separately under the direction of one of the experimenters several days before the lesson

was to be taught. Subjects had been informed in their methods classes that the lesson was considered to be part of their student teaching experience and that they would later receive a summary of their interactions during the lesson and the scores of their pupils on the achievement test. During the one-hour orientation meeting, the student teachers were informed that the purpose of the practice lesson was to observe how they interacted with the randomly selected group of eight pupils as they taught toward a particular objective during a 30- or 40-minute lesson and to test the learning of each child a day later. General suggestions were given on the importance of advanced planning, pupil involvement, and careful pacing of the lesson to assure complete coverage. After familiarizing the student teachers with the content of the lesson and the lesson materials, the nature of the specific objectives for the experimental group to which they had been assigned were carefully explained as follows.

Experiment I. "Why Birds Sing." In Treatment 1 the objective of the lesson was described as having each child remember as many factual details from the lesson as possible when tested the following day. In Treatment 2 the objective of the lesson was described as having every child understand the concepts of "song" and "territory" and the relationship between the two, pointing out that children who understand these concepts should be able to apply them by explaining and predicting events in new situations.

Experiment II. "Rebus." In Treatment 1 the objective of the lesson was described as having each child develop as completely as possible a sight vocabulary of the Rebus symbols in the deck of flash cards and story. It was emphasized that each child must be helped to distinguish clearly each symbol and to know what it represents so that he can remember

it on the test the next day. In Treatment 2 the objective of the lesson was described as having each child understand the principal types of Rebus symbols and the rules governing their construction in order to be able to match new symbols and words on the test the day following the lesson.

Subjects in each experimental group were then given a typed summary of the orientation directions as well as two examples of the criterion test items specific to their lesson objective. Approximately 15 minutes of the orientation meeting were devoted to discussion of the lesson materials, questions by the experimenter to ascertain that subjects understood the lesson material and the objectives, and answering subjects' questions about the lesson content and the procedure. Finally, subjects were told that the planning and execution of the lesson so as best to accomplish the objectives were at the discretion of each student teacher. The importance of careful planning was stressed. It was also emphasized that each child in the group must have a fair opportunity to learn as much as possible within the time of the lesson.

Lesson Process Data

From two to six days after the orientation meeting each student teacher taught the lesson to the group of eight children in a room separate from the regular classroom. Children were seated in a semi-circle in front of the student teacher. The lesson was tape-recorded and observed by one of the investigators or one of their assistants who sat in as unobtrusive a location as possible. The observer did not know to which experimental treatment the student had been assigned. The lesson in Experiment I lasted a maximum of 30 minutes, actual lessons varying between 15 and 30 minutes. The lesson in Experiment II lasted a maximum of forty minutes, ranging between 30 and 40 minutes.

Each lesson was coded on the Individual Cognitive Demand Schedule. Each interchange between teacher and individual pupil was coded in three segments: teacher "cognitive demand," pupil response, and teacher feedback. Teacher demand and pupil response were each coded into one of eleven cognitive demand categories and teacher feedback was coded into one of four categories (Lynch & Ames, 1971b). The cognitive demand categories considered critical to the objectives in Experiment I are Category 4, "Remembering" (Recall Objective); Category 6, "Defining-Classifying," and Category 8, "Inferring" (Concept Mastery Objective). The categories considered critical in Experiment II were Category 2, "Discriminating" (Recall Objective); and Categories 6 and 8 (Concept Mastery Objective). Other cognitive demand categories were examined by post hoc analyses.

After the lesson was coded and checked, the original ICDS codings were examined by another investigator against the audio tape. If disagreement occurred on more than 10% of the codings, the second investigator recoded the lesson from the tape. If 10% or less disagreement occurred, the record was corrected by the original coder. Recodings were then checked by a third coder. Remaining disagreements on codings were resolved in staff conference.

On completion of the lesson, the observer rated the student teacher on a set of 18 five-point items that were intended to measure features of teacher clarity, organization, enthusiasm, and versatility.

Pupil Criterion Tests

Experiment I. The criterion achievement test consisted of 22 items divided into four sections, two sections designed to measure factual recall and two to measure concept mastery and transfer of the key concepts. The

order of the sections of the test was balanced across the 34 lesson groups. Twenty of the items were multiple choice, and two items, one in each of the sections measuring concept mastery, required the child to draw a line around a bird's territory. After each question had been read by the experimenter, each child marked his answers to the multiple choice questions on his answer sheet with an "X" on pictorial representations of answers. The student teacher for each group assisted the experimenter in testing, making certain that each child understood and followed the directions.

Experiment II. The criterion test consisted of 57 multiple-choice items divided into four sections. The first two sections were designed to measure recognition of symbols, giving the symbol and alternative word meanings and giving a word and a series of alternative symbols. The last two sections were designed to measure ability to identify new symbols and to relate new words to symbol categories. Again, directions were given by one of the experimenters and the student teacher assisted with the testing.

Results

Each experiment yielded data on teaching process variables and on pupil learning as reflected in criterion test scores. Each set of data was analyzed separately as a dependent variable. Whenever pupil achievement on the criterion tests entered into an analysis, mean scores of each eight-pupil group, rather than individual scores, were used as the unit of analysis.

Experiment I

Data were obtained on 34 eight-pupil groups with a loss of one group from each treatment group due to illness or equipment failure.

Process variables. Two 2 x 2 multivariate analyses of variance were used to examine the effects of the two treatments (recall vs. concept mastery) and two levels of criterion test achievement (high vs. low) on seven selected process variables. The two multivariate analyses differed in that the Achievement Level factor involved ([illegible] criterion test data (recall or concept mastery). Two levels of test achievement were obtained by splitting the distribution of group means for each of the two tests at approximately the median, utilizing natural breaks in the data and taking into consideration the distribution of scores.

The dependent measures were selected from an original set of 29 process variable indices computed from the ICDS codings of the teacher-pupil interactions in each lesson and from the rating scale data. On the basis of the theoretical interest of the variables, and limiting the selection to ICDS categories relevant to the objectives of the lessons, the following seven indices were entered into the multivariate analysis of variance: percent of total teacher-pupil interchanges coded in the recall category; percent of interchanges coded in the defining-comparing categories combined; percent of interchanges falling in the inference category; percent of interchanges that were pupil initiated; standard deviation of the distribution of interchanges across pupils; total of the ratings of the quality of teaching; and total number of interchanges occurring in each lesson. When entered in the analyses of variance, each percentage index was transformed by an arcsin function (2 arcsin $\sqrt{X}$).

Table 1 shows the summary of the multivariate analysis of variance when the Achievement Level factor was split on recall test scores. Table 2

Insert Table 1 about here
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shows a summary of the MANOVA when the groups were split on the concept mastery test scores.

Insert Table 2 about here

Both analyses show significant multivariate F values for treatment ($p < .001$), indicating that on a weighted combination of the seven process variables there is a significant difference between treatment groups.

On the univariate analyses, two of the cognitive demand categories, percent of recall cognitive demands (CDs) and percent of defining demands, differed significantly between treatment groups. In addition, treatment groups differed significantly on percent of pupil-initiated interchanges and distribution of interchanges among pupils. The means and standard deviations of each treatment group on each process variable are shown in Table 3. The differences between the treatment groups on the cognitive

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Insert Table 3 about here
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demand categories are shown in Figure 2. Teachers in the recall treatment used a higher proportion of recall cognitive demands and a lower proportion

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Insert Figure 2 about here
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of defining demands, distributed their interchanges more evenly among all pupils in their groups, and manifested a significantly higher proportion of pupil-initiated interchanges than did teachers in the concept mastery condition.

When the groups were split on group mean scores on the concept mastery test (see Table 2), the multivariate analysis of variance showed a significant effect on the Achievement Level factor, indicating that the high- and low-achieving groups of pupils differed significantly in the way in which they had been taught. However, no significant univariate F values on the process variables were obtained.

Criterion test results. The reliabilities of the Territory criterion tests were calculated using the Spearman Brown and Kuder Richardson formulas. Table 4 presents the reliability coefficients for each test by treatment group. Correlations between the tests for each treatment group

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Insert Table 4 about here
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are also presented. One factor contributing to the relatively low reliabilities of the criterion tests is the small number of items on these tests. According to Nunnally (1967) a reliability of .50 or .60 is modest but acceptable. The Territory recall test does not seem to be a sufficiently reliable measure and the reliability of the concept mastery test is low.

Although reliabilities of the criterion tests were low, differences in levels of achievement between treatment groups and three grade levels were examined. A separate 2 x 3 multivariate analysis of variance was computed on each criterion test, followed by univariate analyses when a significant multivariate F was found. Table 5 shows the summary of the multivariate

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Insert Table 5 about here
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and univariate analyses of variance on the criterion tests. Significant multivariate Fs were found for both treatment and grade factors.

The univariate analyses show a significant treatment effect on the recall criterion test and a significant grade level effect on the concept mastery test. Means and standard deviations of test scores by treatment and grade level are presented in Table 6. Pupils taught by

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Insert Table 6 about here

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teachers in the recall treatment performed slightly, but significantly, better on the recall criterion test. Using Scheffé's method for post hoc comparisons, significant differences resulted between grade levels one and two ($p < .05$) and one and three ($p < .05$) on the concept mastery test. The differences are in the expected direction.

In summary, Experiment I yielded differences between treatment groups in teaching behavior and partial evidence of differences in pupil achievement. The evidence on the effect of the experimentally induced differences in teaching behavior on pupil achievement is weak, in large part, because of inadequacies in the criterion test. In addition, it should be pointed out that the disproportionately large number of first-grade classes in the sample may account for the difficulty in demonstrating reliable effects.

Experiment II

Process variables. Separate 2 x 2 multivariate analyses of variance, one for each criterion test, with two treatments (recall vs. concept mastery) and two levels of criterion test achievement (high vs. low) were computed on seven process variables. As in Experiment I, the group mean test scores were split near the median at a natural break in the distributions of scores on each criterion test. The seven process variables selected were: percent of total teacher-pupil interchanges coded in the

discriminating category; percent of total interchanges coded in the defining and comparing categories combined; percent of interchanges in the inference category; percent of pupil-initiated interchanges; the standard deviation of the distribution of interchanges across pupils; the total of the ratings of the quality of teaching; and the total number of interchanges occurring in each lesson. Each percentage index was transformed as in Experiment I.

Table 7 presents the summary of the multivariate analysis of variance when the Achievement Level factor was split on the recall test, and

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Insert Table 7 about here

Table 8 is the summary for the concept mastery test.

Insert Table 8 about here

The multivariate F values show significant differences between treatment groups on both tests ($p < .001$). On the treatment factor significant univariate differences appear on percent of discriminating, defining-comparing, and inferring cognitive demands; percent of pupil-initiated interchanges; and total frequency of interchanges. Table 9 gives the means and standard deviations for each process variable. Differences be-

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Insert Table 9 about here
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tween treatment groups on the three ICDS categories are shown in Figure 3.

Insert Figure 3 about here

The proportion of discriminating cognitive demands is greater among teachers in the recall treatment. In contrast, the higher level cognitive demands of defining-comparing and inferring occurred with significantly higher proportions among teachers who were given the set to teach for concept mastery. The concept mastery treatment group also manifested a significantly higher proportion of pupil-initiated interchanges, but the recall-oriented teachers engaged in a significantly higher number of total interchanges.

On the Achievement Level factor, a significant multivariate F resulted on the recall test. The univariate analyses for the recall test split show that the high achieving groups significantly differed from the low achieving groups on percent of discriminating cognitive demands and total number of interchanges. The groups scoring high on the recall test received a higher percentage of discriminating cognitive demands and a higher frequency of interchanges than those scoring low. Table 10 presents means and standard deviations for the achievement level factor.

Insert Table 10 about here

The significant Treatment x Achievement Level MANOVA interaction appears to be due to significant effects of percent of discriminating interchanges and rating scale totals. On percent of discriminating demands the high Achievement Level group in Treatment 1 received a much larger proportion than the other groups. The interaction on the rating scales is disordinal with high-scoring groups in Treatment 1 and low-scoring groups in Treatment 2 receiving relatively higher ratings than the other two subgroups (see Table 10).

Criterion test results. The Spearman Brown and Kuder Richardson reliabilities for the Rebus criterion tests are presented in Table 11. Both tests appear to reach satisfactory levels of reliability.

Insert Table 11 about here

An estimate of the discriminant validity of the tests can be obtained by comparing the test intercorrelations to the reliability coefficients of the individual tests (Campbell & Fiske, 1963). The reliability of the individual test should be higher than correlations between the tests. The correlations between the Rebus tests (.54 and .37) suggest that there is some shared variance between the measures. The difference between the correlations is not significant ($z = 1.77$).

A 2 x 3 (treatment x grade level) multivariate analysis of variance was performed with the criterion test scores as dependent variables (see Table 12). The multivariate analysis yielded significant differences on

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Insert Table 12 about here
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treatment and grade level factors. The univariate analyses show significant differences for treatment and grade level factors on the recall test. Means and standard deviations of the criterion test scores by treatment and grade level are presented in Table 13. Those pupils taught in the

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Insert Table 13 about here
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recall treatment group scored significantly higher. Significant grade level differences occurred between grades four and six ($p < .05$) and grades five and six ($p < .05$) on the recall test (Scheffé post hoc comparison technique). The grade level differences are in the expected direction.

In summary, the results of Experiment II suggest that the pre-teaching orientation produced different patterns of teaching behavior that appear on selected categories of the ICDS. The cognitive demands of the teachers within each lesson orientation were congruent with their objectives. Experiment II also provided evidence that pupil groups scoring higher on the recall achievement test had received a higher proportion of discriminating demands and a higher frequency of interchanges.

Discussion

The experiments served to demonstrate that the Individual Cognitive Demand Schedule is an instrument that is sensitive to some significant features of teachers' instructional interactions with pupils. Predicted variations in experimentally induced teaching behavior were confirmed and partial evidence of predicted effects on pupil achievement was obtained. Data are now available for improvements in the instrument and for designing new instruments. By retaining behavioral categories and avoiding the temptation to combine them in global indices, specific patterns of teaching behavior can be studied in relation to lesson content and pupil behavior. The consequences of being able to define effective teacher behavior as specifically as possible have important implications for the training of teachers.

The results of Experiment II suggest the importance of the relationship between lesson objective and teaching behavior. The effects of types of instructional interactions are relative to the objectives of the lesson. Teachers who were effective in producing recall learning made a higher proportion of discriminating demands and engaged in a higher number of interchanges with their students. This finding also suggests both a content and "process" type of opportunity to learn. The pupils who had

the greatest opportunity to interact with the content materials scored highest as did those students who had the greatest opportunity to interact at a given "process" level.

Comparable results were not found for the concept mastery objective in Experiment II. A possible explanation is that the concept mastery criterion test may not have been sufficiently reliable to obtain an adequate measure of this construct. Secondly, the proportion of defining-comparing and inferring interchanges is low compared to the larger proportion of discriminating demands. Minimum levels of interaction relevant to an objective may be necessary in order to produce learning effects on that objective. In other words, certain types of interactions may be relevant or important to the objectives of a lesson, but it remains a question as to how many or what proportion of these interactions must occur to obtain effects from that teaching behavior. Finally, the sequence of the instruction may be important for concept mastery in that a level of competence must be attained for lower cognitive tasks prior to learning more complex tasks. If this is true, proportion of relevant demands must be investigated in relation to the sequence of the instructional demands and content material.

The results of Experiment I provided further evidence that different patterns of teaching behavior can be obtained by orienting teachers to teach for different objectives. Interpretations of the relationships of process variables to effects on pupil learning are limited because of the low reliabilities of the outcome measures.

The methodology of studying effects of teacher behavior with carefully controlled lesson content and pupil outcome measures (designed to

assess the outcomes of instructional procedures used with that content) is an improvement over earlier approaches. The results of this study provide evidence that differences in teacher behavior can be induced through a relatively short orientation procedure and that the method used in this study can be effective in gathering validation data on classroom observation instruments, and show the importance of establishing a relationship between lesson objectives and teachers' instructional interactions with their students.

The present report has been limited to analysis of only selected portions of the process data. As Rosenshine (1973) has suggested, large numbers of teaching behavior variables can be examined post hoc as guides to further studies. Such analyses of extreme groups are providing clues to new ways to modify teaching behavior experimentally and to measure effects. Future efforts to study effects of teacher behavior should attempt to improve on the methodology of experimental control of preteaching sets, lesson content and context (including pupil variables), pupil acquisition behavior (in-lesson behavior), and postinstructional outcomes.

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Table 1

Experiment I

Summary of Multivariate Analysis of Variance for Seven Teaching Process Variables (Factor B Split on Recall Test)

Source	Univariate Fs (df = 1/30)							Multivariate (df = 7/24)	
	% Recall	% Define-Compare	% Infer	% Pupil Init.	Dist.	Rating	Total Freq.	F	p Less Than
A Treatment	15.44***	4.85*	.09	5.08*	12.72**	3.30	.46	5.25	.001
B Achievement Level	.00	.10	.83	.69	2.41	.04	.26	.58	n.s.
AB Treatment x Achievement Level	.04	1.22	2.98	.02	3.26	3.14	.02	2.35	n.s.

*$p < .05$

**$p < .01$

***$p < .001$

Table 2

Experiment I

Summary of Multivariate Analysis of Variance for Seven Teaching Process Variables (Factor B Split on Concept Mastery Test)

Source	Univariate Fs (df = 1/30)							Multivariate (df = 7/24)	
	% Recall	% Define-Compare	% Infer	% Pupil Init.	Dist.	Rating	Total Freq.	F	p Less Than
A Treatment	15.56***	4.92*	.09	4.97*	11.53**	3.21	.47	5.17	.001
B Achievement Level	.22	1.64	1.34	.05	1.16	1.21	.15	2.47	.046
AB Treatment x Achievement Level	.06	.13	.04	.01	1.18	1.07	.68	1.02	n.s.

*p < .05

**p < .01

***p < .001

Table 3

Experiment I

Means and Standard Deviations of Seven Process Variables as a Function of Treatment Group

Process Variables	Treatment 1 (n = 18)		Treatment 2 (n = 16)	
	$\bar{X}$	SD	$\bar{X}$	SD
% Recall	33.8	9.9	20.2	9.2
% Define-Compare	18.4	9.6	25.9	9.7
% Inferring	30.4	13.5	29.5	16.9
% Pupil-Initiated	17.9	11.7	9.9	7.9
Distribution	46.3	18.9	25.8	16.0
Rating	54.4	15.3	62.9	12.0
Total Interchanges	68.1	24.8	62.6	19.9

Table 4

Experiment I

Reliability Coefficients for the Criterion Tests Blocked by Treatment

Treatment	Recall Test (12 items)		Concept Mastery Test (10 items)		Intertest Correlation
	SB	KR_{20}	SB	KR_{20}	
Recall (n = 137)	.16	.37	.53	.44	.33
Concept Mastery (n = 143)	.28	.39	.62	.59	.34

Table 5

Experiment I

Summary of Multivariate and Univariate Analyses of Variance of Criterion Test Scores

Source	df	Univariate Analysis				Multivariate Analysis	
		Recall		Concept Mastery			
		MS	F	MS	F	F (df = 4/58)	p Less Than
A Treatment	1	8.47	6.67**	.32	.21	4.20	.025
B Grade	2	3.24	2.55	13.84	9.12***	4.03	.006
AB Treatment x Grade	2	2.32	1.83	.57	.37	1.14	n.s.
Error	30	1.51		1.27			

**$p < .01$

***$p < .001$

Table 6

Experiment I

Mean Pupil Criterion Test Scores as a Function of Treatment Group and Grade Level

Treatment	Grade	n*	Recall Test		Concept Mastery Test	
			$\bar{X}$	SD	$\bar{X}$	SD
Treatment 1	1	9	8.0	1.0	4.0	1.0
	2	4	7.8	.4	5.7	.8
	3	5	8.7	1.0	6.1	1.3
	Total	18	8.1	.9	5.0	1.4
Treatment 2	1	8	6.4	1.5	4.3	1.0
	2	6	8.0	1.1	6.0	1.3
	3	4	7.5	1.2	5.6	2.2
	Total	18	7.2	1.1	5.1	1.6

*n = number of groups of eight pupils each.

Table 7

Experiment II

Summary of Multivariate Analysis of Variance for Seven Teaching Process Variables (Factor B Split on Recall Test)

Source	Univariate Fs (df = 1/30)							Multivariate (df = 7/24)	
	% Discrim.	% Define-Compare	% Infer	% Pupil Init.	Dist.	Rating	Total Freq.	F	p Less Than
A Treatment	43.68***	12.25***	20.10***	5.12*	1.17	1.10	11.78**	8.92	.001
B Achievement Level	20.71***	4.02	2.14	2.20	3.21	.23	7.76**	4.25	.004
AB Treatment x Achievement Level	9.58**	.69	.01	.01	.17	4.50*	.44	2.92	.023

*p < .05

**p < .01

***p < .001

Table 8

Experiment II

Summary of Multivariate Analysis of Variance for Seven Teaching Process Variables (Factor B Split on Concept Mastery Test

Source	Univariate Fs (df = 1/30)							Multivariate (df = 7/24)	
	% Discrim.	% Define-Compare	% Infer	% Pupil Init.	Dist.	Rating	Total Freq.	F	p Less Than
A Treatment	22.50***	11.37**	19.32***	5.04*	1.07	1.28	9.84**	4.91	.001
B Achievement Level	.80	.65	.09	1.35	.01	10.00	1.92	1.42	n.s.
AB Treatment x Achievement Level	.25	1.56	.81	.34	.63	.41	.01	.81	n.s.

*p < .05

**p < .01

***p < .001

Table 9

Experiment II

Means and Standard Deviations of Seven Process Variables

as a Function of Treatment Group

Process Variables	Treatment 1 (n = 17)		Treatment 2 (n = 17)	
	$\bar{X}$	SD	$\bar{X}$	SD
% Discriminating	57.1	17.0	34.5	8.7
% Defining-Comparing	1.9	2.4	5.9	5.0
% Inferring	8.6	5.9	26.6	14.5
% Pupil Initiated	1.2	.9	3.2	3.4
Distribution	3.2	2.4	4.0	2.3
Rating	35.7	6.0	33.4	7.2
Total Interchanges	192.5	65.1	133.5	42.1

Table 10

Experiment II

Means and Standard Deviations for Variables Significant on the Achievement Level (B)

and Achievement Level x Treatment (AB) Effects on the Recall Test

Process Variables	Treatment 1				Treatment 2			
	High Achieve. Level		Low Achieve. Level		High Achieve. Level		Low Achieve. Level	
	$\bar{X}$	SD	$\bar{X}$	SD	$\bar{X}$	SD	$\bar{X}$	SD
Total Frequency (B)	212.1	52.3	145.6	74.4	164.5	29.5	123.9	41.5
% Discriminating (B, AB)	65.5	7.4	36.8	16.9	38.0	9.4	33.4	8.5
Rating (AB)	37.5	5.5	31.4	5.5	30.0	8.8	34.5	6.7

Table 11

Experiment II

Reliability Coefficients for the Achievement Tests Blocked by Treatment

Treatment	Recall Test (24 items)		Concept Mastery Test (33 items)		Intertest Correlation
	SB	KR_{20}	SB	KR_{20}	
Recall (n = 142)	.78	.79	.64	.57	.54
Concept Mastery (n = 131)	.82	.79	.63	.55	.37

Table 12

Experiment II

Summary of Multivariate and Univariate Analyses of

Variance of Criterion Test Scores

Source	df	Univariate Analysis				Multivariate Analysis	
		Recall		Concept Mastery			
		MS	F	MS	F	F (df = 4/58)	p Less Than
A Treatment	1	102.15	17.52***	.03	.02	9.46	.001
B Grade	2	36.09	6.19**	.91	.60	2.76	.05
AB Treatment x Grade	2	8.83	1.51	.10	.07	.89	n.s.
Error	30	5.83		1.50			

**p < .01

***p < .001

Table 13

Experiment II

Mean Pupil Criterion Test Scores as a Function of Treatment Group and Grade Level

Treatment	Grade	n*	Recall Test		Concept Mastery Test	
			$\overline{X}$	SD	$\overline{X}$	SD
Treatment 1	4	8	18.6	2.3	11.1	1.1
	5	5	17.8	2.4	10.7	1.0
	6	5	20.0	2.3	11.5	1.8
	Total	18	18.7	2.4	11.1	1.3
Treatment 2	4	8	14.6	2.3	11.0	.6
	5	6	14.0	2.6	10.9	1.0
	6	4	19.3	2.8	11.3	1.9
	Total	18	15.3	3.2	11.0	1.1

*n = number of groups of eight pupils each.

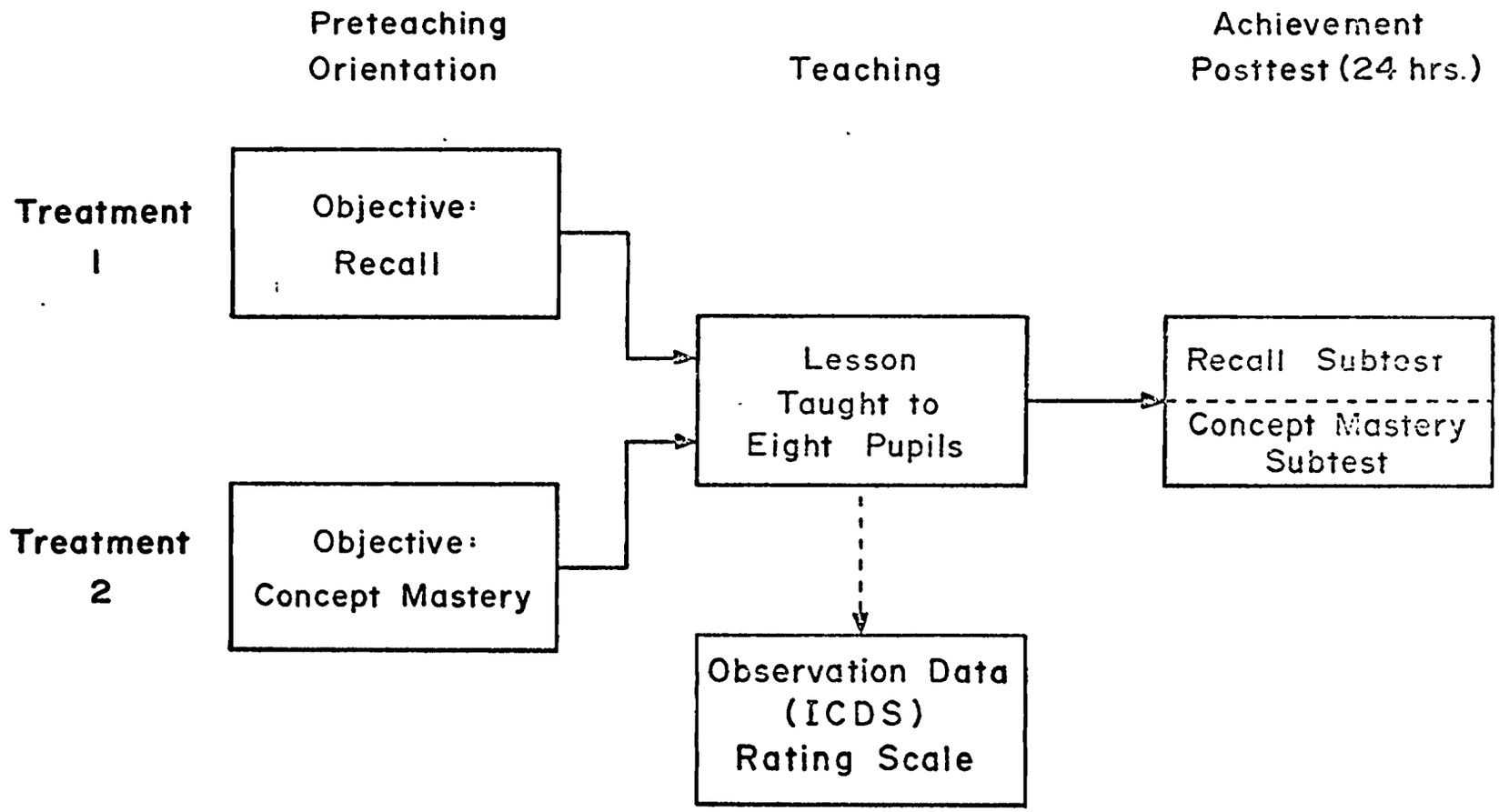

Fig. 1. Pictorial description of Experiments I and II.

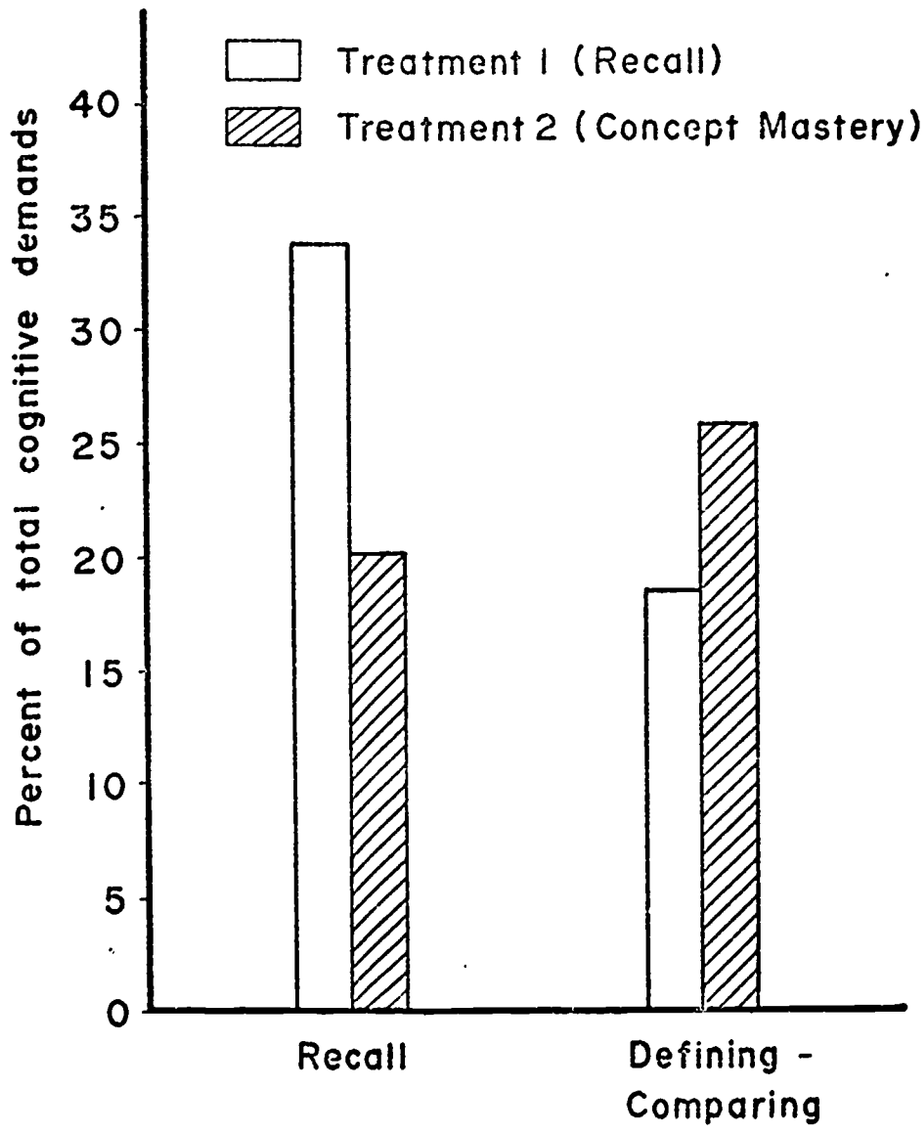

Fig. 2. Treatment group differences on cognitive demand categories in Experiment I.

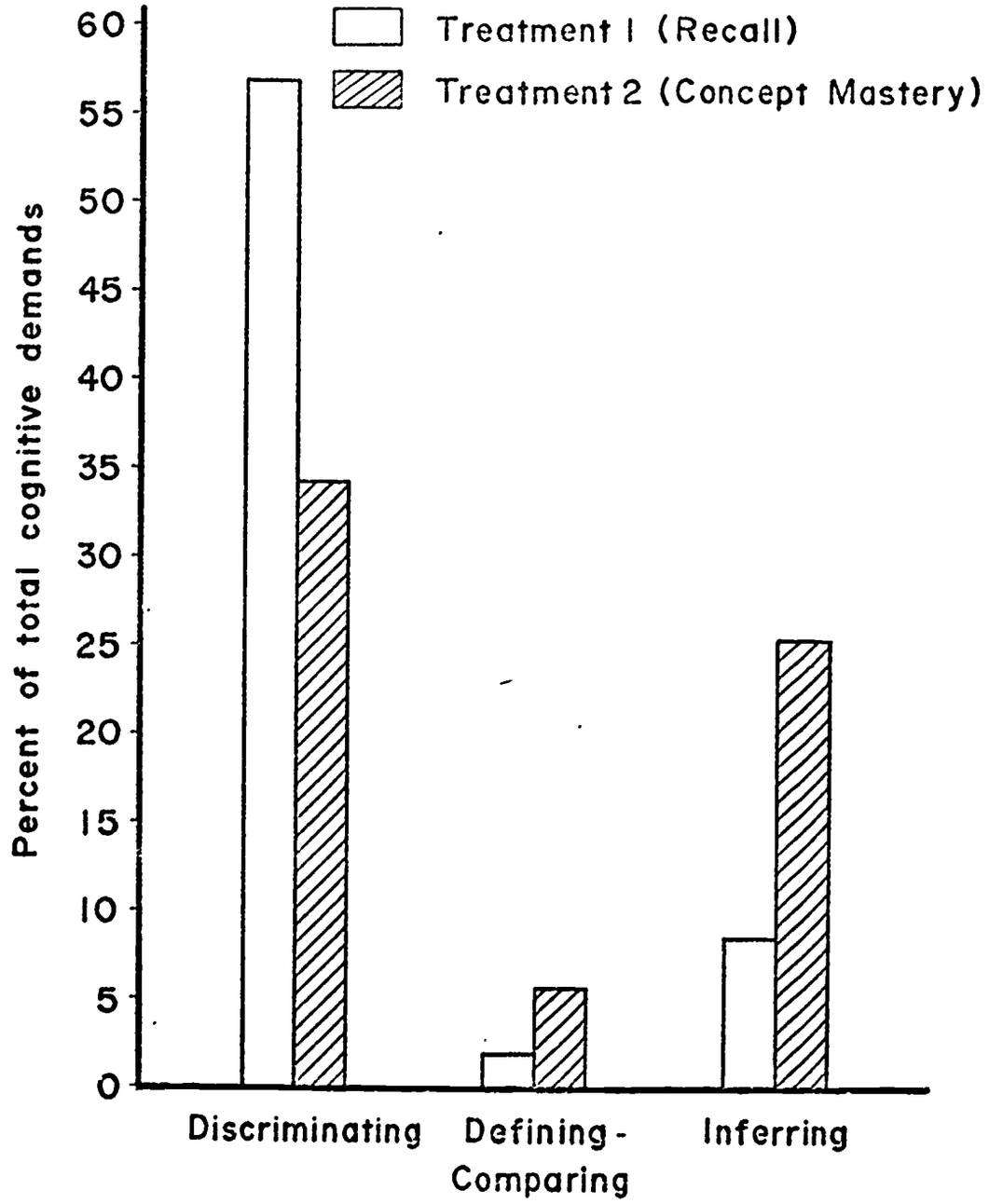

Fig. 3. Treatment group differences on cognitive demand categories in Experiment II.